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Mössbauer studies of implantation damage in iron and nickel

Reintsema, Sipke Roelf

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SUMMARY

In this thesis we describe Mössbauer effect investigations on lattice damage induced by implantation of ^{125}I, ^{129m}Te, ^{131}I and ^{133}Xe in iron and of ^{129m}Te in nickel. The hyperfine interaction of the implanted radioactive nuclei yields information on the defect structure around the implanted probes and its annealing behaviour. We found that room temperature implanted impurities come to rest for a large part (about 65 % for Te, 45 % for I and 35 % for Xe implanted in iron and about 60 % for Te implanted in nickel) on substitutional lattice sites, while in all cases about 15 to 25 % of the implanted atoms have associated with one nearest-neighbour vacancy. The remaining part of the implanted atoms comes to rest at sites where they are associated with more than one vacancy. These sites are often not uniquely defined. The magnetic hyperfine fields of these sites have been determined for all impurities considered. The magnitude of the magnetic hyperfine field for a particular impurity is found to decrease as the number of associated vacancies increases.

The decrease in the substitutional fraction in iron, when going from Te via I to Xe, is due to the difference in volume excess of the implanted impurities: whereas Te fits reasonably in the iron lattice, I (which may be assumed to be present as I^- in iron) and Xe are much too large and therefore I^- and Xe represent deep traps for vacancies in iron. Annealing measurements have shown that the most stable site for xenon in iron is a site where the xenon atom is associated with two or three vacancies in its two nearest neighbour shells. These measurements have also yielded a value for the activation energy for migration of vacancies in iron: $E_m = 1.25 \pm 0.1$ eV.

For Te in iron it has been shown that the "clean" substitu-

tional or high-field fraction deduced from Mössbauer effect measurements is 65 ± 3 %, while backscatter channeling yields a substitutional fraction of 84 ± 8 %. This discrepancy is due to the fact that Te atoms associated with a nearest-neighbour vacancy (discerned by Mössbauer spectroscopy as a separate component) are displaced so little from the substitutional sites that they are still "seen" as substitutional by the channeling method. The same behaviour for Te is found when it is implanted in nickel.

Spectra obtained after implantation of Te and Xe in iron at 7 K, which is far below the first recovery stage in iron, only yield remarkably small differences compared with spectra obtained after room temperature implantation. This must be due to the fact that host interstitials, formed during the implantations and normally found to become mobile at about 100 K, have annealed during the implantation by the high local density of energy deposited in the lattice by each implanted atom.